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ABSTRACT

To examine the influence of two variables--prompting versus confirmation, and verbalization--on learning, 60 high school subjects used programed instruction under six randomly assigned treatment conditions to learn to write computer programs. The rules group periodically wrote out the programing rules; the naming group subjects named the rules; the computer-programing-only group wrote the programs without any verbalization. In addition, subjects were required to write their answers to the programed instruction questions either after (prompting) or prior to (confirmation) being given the explicit information requested. The effects of the conditions were measured on criterion tests. In all cases intelligence levels of subjects were related to test scores; no intelligence-learning condition interaction effects appeared. During learning the prompting condition was superior; on the criterion tests the confirmation group was superior. On the verbalization variable the rules group performed worse than the other two. The rules group also revealed the greatest test score variance. There was no significant difference between the computer-programing-only and the naming groups. (KB)

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EFFECTS OF VERBALIZATION AND INFORMATION ON PROBLEM SOLVING IN PROGRAMMED LEARNING[1]

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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The present study was an attempt to examine the possible influence of two factors—prompting versus confirmation, and verbalization—on learning in a conceptual problem-solving context.

Six independent groups of Ss were required in a programmed instruction (PI) environment to learn to write computer programs (CP's) with the additional requirement that: (a) S periodically write out the rules he was using to write computer programs (rules group), or (b) he only name these rules (naming group), or (c) he write CP's without any verbalization (CP-only group). In addition, S was required to write his answers during the PI either (1) after (prompting), or (2) prior to (confirmation) being given the explicit information requested. Treatments were administered during the PI training and their effects were noted on criterion tests given at the end of each of two phases of programmed instruction.

Method

Subjects

Subjects consisted of 60 paid volunteer high school students, who were informed beforehand that they were to be paid between a $1.50 and $2.50 per hour depending upon the proficiency they exhibited in the programmed instruction.

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1/ The research reported here was conducted by the authors while employed by the Human Resources Research Office, The George Washington University, operating under contract with the Department of the Army. Opinions and conclusions are those of the authors and do not necessarily represent those of the University or the Department of the Army.

Ss were assigned at random to one of the six conditions in a 2 by 3 factorial design---prompting vs. confirmation as one factor and the three verbalization conditions as the other. A diagram of the design appears in Table 1 of your handout.

Materials

The material, a programmed instructional booklet consisting of 90 pages, including the criterion test, constituted a sub-course of the Programming Specialist Course at the U.S. Army Signal School and covered what are called the primary programming commands of a business-type digital computer. In addition, an introduction to a symbolic language for computer programming was used. The content was derived from a task analysis of computer programming. The criterion tests consisted of actual computer problems which were submitted by a programmers' group from Ft. Huachuca and from programming instructors at Ft. Monmouth Signal School. Where necessary, the problems were simplified by removing aspects which would require techniques beyond the scope of the course. A verbal and clerical portion of the Army Classification Battery was used to classify Ss by intelligence level.

Procedure

The course was administered in two phases with a retention test following each phase. On Day One, for a maximum of four hours, students were given Phase I, the section concerned with primary programming commands. On Day Two, they were given a retention test consisting of four computer problems to be programmed. This was not timed but all were through within 30 minutes. Immediately following this test, they were given Phase II of the course, which covered more complex computer programs. On Day Three, Retention Test 2, covering all the course material, was given, followed by the intelligence measure.

The learning task was writing computer programs of increasing complexity, with the additional requirements imposed by the experimental treatments. As a secondary part of the criterion tests for Phases I and II, we also measured the ability of all Ss to write the rules and the names of the rules which they used in writing the CP's. The students were allowed a maximum of four hours on each of the two days of training. Only one or two students required that much time on either day. Booklets were checked for each student at the end of his working day to ensure that he was actually attempting to learn the material and not simply putting in time for an hourly rate. This kind of problem never really occurred since all students were highly motivated to perform--as a matter of fact, stayed after hours to ask further questions about the course work.

Results

Before discussing the treatment findings, note once more that on Tests 1 and 2 we measured three dependent variables: principally, ability to write computer programs; in addition, writing rules; and naming the rules. The retention tests involved only CP's.

Question 1. Did the Ss learn? Unequivocally, yes. On the test for Phase I, nearly two-thirds of the Ss achieved 80% or better on the program-writing material, and over a third of the Ss scored 90% or more. Results for Test 2 were comparable. The scores on the criterion tests for computer programming and scores on the retention tests are given in Table 2 of your handout.

Question 2. What was the effect of intelligence level on success in the course? In all cases the intelligence indicator was significantly related to the criterion scores. No interactions appeared between intelligence level and the experimental treatments.

Question 3 What treatment effects were there? For both Phases I and II, prompting and confirmation treatments did not differ significantly in time to complete the course.

The data indicate that the principal reason for significance of the F ratios in Phase I for the verbalization variable is that the rules group took longer to complete the material than did the other two verbalization groups. In Phase II the naming group was faster than either of the other two groups. Since the CP-only group did not have the rules or naming items in their programmed instructional materials, their number of pages were almost half the number of pages of the other two groups. Note that despite this, the CP-only group did not finish faster than the naming group in either Phase I or Phase II. Because of this fact and because of the fact that achievement generally was so high and negatively correlated with learning time, further analyses of variance on the criterion tests were done with a time-weighted score for each individual. We simply divided S's criterion score by his time to complete the course. This enabled individual differences to be revealed more readily.

The general treatment effects on the time-weighted scores were as follows: (1) First consider the prompting-confirmation results. During learning, the prompting condition was significantly superior to confirmation, however, on the criterion tests the groups did not differ significantly and if anything, as seen in Table 3, the confirmation group tended to be superior. The same tendency holds for the retention tests. In fact, comparing prompting vs confirmation across the three intelligence levels and simply looking at the number of times the confirmation group's means exceeded those of the prompting group, we find, including Test 1, Test 2, and both retention tests, a ratio of 17 to 6 in favor of superiority of the confirmation group.

(2) Turning to the F ratios for the other variable, verbalization, we find that the Ss required to write the rules during training did worse in writing computer programs on the criterion tests than Ss who had simply to name the rules during training or Ss who learned without either additional requirement. It should be noted that, as revealed by the unweighted means in Table 2, the rules groups also had the highest variance on the criterion tests. This effect, incidentally, was particularly evident with the Ss of lower intelligence. Looking at Table 4 illustrating these results, we find that if we simply order the means of the three groups on CP writing, the criterion measure of principal interest, the mean of the rules group is consistently lower than the mean of the naming group or the CP-only group. Two-group comparisons indicate this difference is the basis for statistical significance in all cases. Suggestions for further study--already underway, including an extensive replication of the current experiment--are revealed by the change in the ordering on the program-writing measure between Test 1 and Test 2 for the naming group versus the CP-only group. On Test 1 and Retention Test 1 the CP-only group was best, while on Test 2 and Retention Test 2 the naming group seemed to be superior. Again, this is just a tendency and not statistically significant. This particular comparison will be followed up in the larger study dealing with the same introductory content as well as the more complex concepts of computer programming. It may be, as noted in a recent study by Gagné and Smith (1962), that the importance of verbalization of principles is not revealed until the material is much more complex.

One final finding, as seen in Table 5, was that the criterial measures were highly reliable.

Discussion

The data from the prompting versus confirmation comparison indicate the necessity for caution in applying findings established in paired-associate or serial learning to paradigms involving a highly organized, abstracted type of learning, such as learning how to write computer programs. In the latter case, the responses we are teaching are more of a mediated set of knowledges rather than actual mechanical responses which the S performs during the course itself. These paradigmatic differences are discussed at some greater length in the handout. Viewed in another light, the prompting-confirmation data also speak to the point concerning the relation between error rate during learning and success on the criterion. Our data indicate that in the present context the effect of error rate during learning washed out or even tended to be negatively related to errors in end of course testing.

Secondly, with respect to verbalization, we are quite aware that what's in a name is definitely important. The ways in which we ask the S to verbalize must be taken into account when inferring the effects of this technique; e.g., either by writing or by oral recitation. The present experiment was but a first attempt to study effects of verbalization of rules.

Previously, Gagné and Smith (1962) found an advantage to requiring the S to compose and verbalize the rules he was using in a concept identification task. However, in the present case the rules the S was required to verbalize differed in that they were contextually constrained. First, Ss were required to closely paraphrase the rule in a completion format. And secondly, if a computer command were involved, the S was not simply asked the general principle behind the command but rather he was asked to interpret a computer instruction with the command applied to a specific, meaningful program context. Requiring the S to verbalize contextual rules in this manner in addition to solving

problems should indicate the value of teaching Ss to state the concepts mediating the specific problem-solution performance which he is being taught (in this case, on computer program writing). The naming responses which were required in his problem-solving performances should indicate the value of the use of mnemonics or reduced cues as an aid to learning the performance oriented response (computer programming procedure).

We can speculate that, in attempting to account for the possible advantage of having S name the rules as opposed to regurgitating a set of words comprising a rule as we have given it to him, we must take into account the possibility that the S will perform best when he can use, where possible, his own repertoire of verbal responses. Gagné and Smith provided the widest possible latitude in this framework by allowing the S to compose the rule himself as he solved a series of problems, and this procedure seemed to help. Ericksen (1962) has also advocated this approach. The importance of the current study is seen as a preliminary investigation to be replicated as part of a larger research project aimed at investigating the role of learning factors in PI concerning tasks of a conceptual nature.

Appendix to Discussion

Much of the research concerning the effects of various learning factors in programmed instruction (PI) has been conducted with paired-associates or serial learning. (For an excellent discussion of problems in doing PI research within a conceptual context, see Traub, 1964.) For example, a series of studies by Cook, et al, (e.g., 1960) and Angell and Lumsdaine (1961), as well as other authors, found that prompting was more effective than confirmation for learning. Little research, however, has been done where experimental treatments have been manipulated under connected, conceptual discourse, hierarchically organized. (A recent study by Hickey and Newton, 1964, is welcomed attempt.) Yet this is precisely the medium for most if not all programmed instructional course work. One study by Gagné and Brown (1961) compared various combinations of prompting and confirmation (although they did not use these terms) in a more conceptual framework, namely the learning of principles for generating number series. In their study, the guided discovery group, the medium difficulty condition, appeared to be most effective while the rule and example condition, low difficulty level, was least effective.

Thus, it might appear that Angell and Lumsdaine's results indicate the Ss should be given substantial information before being required to respond, while Gagné and Brown's results indicate that they should be required to discover the answers themselves. Aside from the differences in the paradigms used, many other factors were not controlled across experiments. For example, the contiguity of correct stimulus-response association was not held constant across prompting and confirmation conditions. Also, correct responses were not necessarily given the sam number of times or in the same manner. A meaningful comparison of prompting versus confirmation should simply manipulate the amount of information given to the S prior to requiring him to respond.

A second factor of interest in training for conceptual, problem-solving proficiency is the act of verbalizing during the training conditions the rules which are being used in the problem solution. Recently, a study by Gagné and Smith (1962) suggested that the verbalization takes on importance as the complexity of the problem increases.

Traub's recent study (1964) was an interesting attempt to study the effects of heterogeneity vs. homogeneity of training (teaching addition to children) on subsequent problem-solving proficiency. This well-controlled study was a pleasant exception to the previous work in the area. However, it is quite possible that the variable he manipulated was complexity of training rather than heterogeneity.

TABLE #1: Experimental Design in PI Training for Computer Programming (CP)

(N = 60)

Training Variations	Student writes computer programs and their rules	the names of the rules	nothing else
Prompting (answer given first)	10	9*	10
Confirmation (answer is discovered)	10	11	10

*Replacement of one S and error in printing resulted in inequality.

TABLE #2: UNweighted Means on CP (computer program) Writing Criterion

(All numbers in tables have been rounded to nearest integer.)

Test #1 (Maximum possible = 52)

Training Treatments	Rules + CP	Naming + CP	CP only	Row $\bar{x}$	%
Prompt	39	43	47	43	83
Confirm	43	49	44	45	87
Col. $\bar{x}$	41	46	46		
%	79	88	88		

Test #2 (Max.=89)

	R	N	-	Row $\bar{x}$	%
P	66	66	75	69	78
C	69	79	77	75	84
Col. $\bar{x}$	68	73	76		
%	76	82	85		

Retention 1 (Max.=62)

	R	N	-	Row $\bar{x}$	%
P	47	50	52	50	80
C	46	57	52	52	84
Col. $\bar{x}$	47	54	52		
%	76	87	84		

Retention 2 (Max.=60)

	R	N	-	Row $\bar{x}$	%
P	37	42	41	40	67
C	46	54	40	47	78
Col. $\bar{x}$	42	48	41		
%	70	80	68		

T_1 Variances*

220	75	54
105	13	57

*x^2 = 15.517
df = 5, P < .01

T_2 Variances*

327	248	113
378	58	143

*x^2 = 18.155
df = 5, P < .01

R_1 Variances

332	144	126
287	37	171

x^2 = 10.410
NS
(11.07 for .05)

R_2 Variances

417	193	241
332	69	214

x^2 = 6.857
NS

TABLE #3: Time-Weighted Means on Criterion (Score = $\frac{\text{Achievement}}{\text{Time}}$ X 1000)

Prompt vs. Confirmation

Dependent Variable	Test #1		Test #2		Retention Test #1		Retention Test #2	
	Prompt	Confirmation	Prompt	Confirmation	Prompt	Confirmation	Prompt	Confirmation
CP Writing	368	389	719	750	427	442	423	468
Naming the Rule	34	38	49	46				
Stating the Rule	17	24	21	19				

TABLE #4: Time-Weighted Means on Criterion (Score = $\frac{\text{Achievement}}{\text{Time}}$ X 1000)

Verbalization Variable

	Test #1			Test #2			Retention Test #1			Retention Test #2		
	CP Only	CP + Rules	CP + Naming	CP Only	CP + Rules	CP + Naming	Problem Solving	Rules	Naming	Problem Solving	Rules	Naming
CP Writing	2/ 426	314	397	5/ 753	624	793	6/ 486	356	463	7/ 412	385	521
Naming the Rules	1/ 40	29	40	4/ 42	39	55						
Stating the Rules	20	24	20	3/ 15	27	19						

1/ $F = 3.815$, $df = 2/5$

2/ $F = 5.053$, $P < .05$

3/ $F = 3.990$, $P < .05$

4/ $F = 7.187$, $P < .01$

5/ $F = 4.244$, $P < .05$

6/ $F = 4.571$, $P < .05$

7/ $F = 4.068$, $P < .05$

TABLE #5: Hoyt Reliability Scores on Criterion by Verbalization Treatment and Total Sample

	Rules + CP				Naming + CP				CP-only			
	Test	Test	Ret.	Ret.	Test	Test	Ret.	Ret.	Test	Test	Ret.	Ret.
CP Writing	xxx .93	xxx .88	xxx .87	xxx .93	xxx .84	xx .71	xxx .80	xxx .85	xxx .85	x .63	xxx .91	xxx .79
Stating Rules	*	xx .76			*	NS			*	NS		
Naming	*	xx .71			*	NS			*	x .67		

*Not available

TOTAL SAMPLE

	Test #1	Test #2	Retention #1	Retention #2
CP Writing	xxx .89	xx .79	xxx .86	xxx .86
Stating Rules	*	x .63		
Naming	*	x .63		

x P < .05
xx P < .01
xxx P < .001

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